Simulation of a multiterminal system for container handling

Abstract A generic simulation model structure for the design and evaluation of multiterminal systems for container handling is proposed. A model is constructed by combining three basic functions: transport, transfer, and stacking. It can be used for further detailing of the subsystems in the terminal complex while preserving the container flow patterns in the system. The modeling approach has been applied to the complete set of existing and future terminals in the Rotterdam port area, using forecasts of containers flows, statistical data from existing terminals, expert opinions, and conceptual designs of the new port area called “second Maasvlakte”. Experimental results including the requirements for deep-sea quay lengths, storage capacities, and equipment for interterminal transport are shown. Further traffic flows on the terminal infrastructure are determined, and the consequences of applying security scanning of containers are evaluated.

Keywords Container terminal · Simulation · Process interaction method · Strategic · Conceptual design

1 Introduction

Container terminals play an important role as a node in many supply chains. A container terminal is an area for container transshipment between various transport modalities. The main modalities are deep-sea, short-sea, inland waterway, road, and rail. Container flows worldwide are growing very rapidly and it is expected that this growth will continue during the next decades. A new generation of deep-sea container vessels, with a capacity of 8,000–10,000 “20-ft container equivalent

J. A. Ottjes · H. P. M. Veeke · M. B. Duinkerken · J. C. Rijsenbrij · G. Lodewijks
Faculty of Mechanical, Maritime and Materials Engineering, Delft University of Technology, Mekelweg 2, 2628 CD Delft, The Netherlands
E-mail: j.a.ottjes@tudelft.nl, h.p.m.veeke@tudelft.nl, m.b.duinkerken@tudelft.nl, j.c.rijsenbrij@tudelft.nl, g.lodewijks@tudelft.nl
units” (TEU), is coming. Even larger vessels are under development. These developments urge container main ports to reconsider their equipment and logistics or even to expand.

Recently, the Dutch government decided to extend the Rotterdam port area with the so-called “second Maasvlakte” (MV2) to be reclaimed from the North Sea. This area will be mainly used for container handling and it is anticipated that a number of container terminals will be established on it. We will call this a “multiterminal.” The question to be answered is how to arrange these terminals. One theoretical option is to have a number of autonomous deep-sea terminals, owned by different parties, each facilitating all necessary modalities. These are called “compact” terminals. Another possibility is to aim at functional specialization per modality. This would imply separate terminals for deep-sea, rail, barge, and truck handling. These are called “dedicated” terminals. Between these two extremes, there are numerous mixed multiterminal configurations possible. Each multiterminal will need transportation facilities between the individual terminals, the so-called interterminal transport (ITT).

A research project has been carried out with the main objective to evaluate conceptual multiterminal designs for the second Maasvlakte, including interterminal transport systems, in coherence with the existing terminals on the first Maasvlakte (MV1). It is assumed that both intra- and interterminal transport will take place with automated guided vehicles (AGV). An AGV autonomously drives to its destination, but needs an external device for loading and unloading a container.

This paper covers the first part of the research project, concerning a strategic logistic simulation study of the complete set of existing and planned future terminals in the Rotterdam Maasvlakte area to support the design activities for MV2. The research goal of this study is to determine, for a number of conceptual multiterminal designs, the requirements with respect to the number of AGVs, the capacity of the interterminal transport infrastructure, the sea berth length, the stacking capacity, and the influence of safety measures. It was decided to use simulation to be able to deal with stochastic effects already in the early design stage. In a later phase of the design process, detailed studies on subsystems like individual terminals and the interterminal transport of containers are anticipated. Therefore, the simulation model should be developed in such a way that it is reusable as a common basis for the parallel development of detailed submodels and can be used as a consistent input framework for the submodels.

This paper is organized as follows: In “Container terminals,” we analyze the problem under investigation and formulate the research demands. “Container terminal modeling” presents the model framework, and “Model construction” discusses the model construction. “Modeling the Maasvlakte terminals” describes the application of the model and a selection of the results. “Results” contains conclusions and future research topics.

2 Container terminals

In this section, some typical container-terminal related issues will be analyzed, and the research question will be formulated.